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RESEARCH ARTICLE

Eco-Friendly Synthesis, Spectral, Morphological Analysis of Cobalt Oxide Nanoparticles (Co_3O_4NPs) Mediated by Leaves Extract of *Pedalium murex L* and its Anti-bacterial, Antifungal, Antioxidant and Anticancer (MCF-7 Cell Line) Study

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Abstract

Objectives: To evaluate the structural, morphological and biomedical application of green synthesized cobalt oxide nanoparticles. **Methods:** The leaf extracts of *Pedalium murex L.* have been used as a stabilizing and reducing agent for the synthesis of cobalt oxide nanoparticles. In the present study, green synthesized cobalt oxide nanoparticles have been characterized by three types of spectrometry, such as Ultra-Violet, Infra-red and Fluorescence spectrometers; the shape and size of the cobalt oxide nanoparticles were analyzed by X-ray diffraction, Dynamic light scattering, SEM with EDS and TEM analysis; biomedical application of the cobalt oxide nanoparticles were screened for antibacterial and antifungal activity by disc diffusion method. The activities were tested against various bacterial and fungal microorganisms including *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Bacillus cereus, Candida albicans* and *Trichoderma viride*. Antioxidant activity was evaluated by DPPH radical methods and anticancer activity was tested on the MCF-7 cell line. **Findings:** The Greener method is very useful environmentally in reducing hazardous solvents and some other chemical reagents. UV spectrum has shown an absorption maximum at 532.28 and 797.83 nm; similarly of FTIR spectrum has shown frequencies at 663cm^{-1} and 570 cm^{-1}, and FL has shown absorption at 765nm. The present work authenticated that the inclusion of *Pedalium murex L*. extracts enhances the reducing property. Two absorption maximum and IR dual fre-

quencies indicated the Co^{2+} and Co^{3+} ions in the spinel structure of Co_3O_4NPs. The particle size from Scherrer's formula has been obtained as ~21.8nm, which indicates the maximum biological applications for its minimum size. The morphology of present NPs has been obtained as a spherical shape by SEM analysis and spherical and rod shapes by TEM analysis. The antibacterial efficacy has been observed and pointed out that the present NPs have acted as better antibacterial agents against *Pseudomonas aeruginosa*. The Co_3O_4NPs showed a good response against cancer cells (MCF-7) ($IC_{50;80}$ g/mL), indicating its greater efficacy in killing cancer cells. **Novelty:** The green synthesis of Co_3O_4NPs was achieved with *Pedalium murex L.* leaf extract with the application of antibacterial and antifungal activity, in addition to potential application in cancer treatment.
Keywords: Eco-friendly Synthesis; *Pedalium murex L*; Co_3O_4NPs; Antibacterial; Antifungal Antioxidant and Anticancer activity

1 Introduction

Nanotechnology is one of the fastest growing multi-disciplinary fields, which holds a promising future because of the near relationship between fundamental and carried out components of this subject. Because of their tremendous physicochemical properties, cobalt nanoparticles (NPs) have been effectively carried out in numerous fields, consisting of aptness care, synthetic biology and cell conveyance[(1)]. Among numerous nanoparticles, Co_3O_4NPs have received precise attention because of their precise morphologies, balance, and managed geometry. Co_3O_4NPs have been used in large part in various electronic and sensing gadgets, coating materials, records wadding, and molecular switches. Apart from these, they've been additionally applied within the scenarios and treatments of various illnesses[(2)]. Especially, Co_3O_4NPs possess notable antimicrobial activities against several microorganisms. Because of this, they were effectively used in special clinical merchandise, consisting of in coating materials of catheters for cerebrospinal fluid drainage, touch lenses, and other scientific devices. Studies are now focused on green synthesis of nanoparticles due to the fact this organic-based totally procedure isn't the best environment-friendly, price-effective and speedy, but the chemically synthesized nanoparticles may also show off pharmacological residual consequences in the atmosphere. So, because of this, in metallic nanoparticles production, microorganisms are also used. The development of techniques benign to the surroundings for biogenetic manufacturing is now creating more interest due to the simplicity of the methods and flexibility. Due to their amenability to organic functionalization, organic nanoparticles are receiving vital programs in the field of medicine. The biomolecules present in plant extracts may be used in the synthesis of nanoparticles via a single step synthesis system[(3)]. Medicinal plants were historical remedies for human illnesses. Plants are utilized in contemporary remedies where they occupy a full-size location as raw fabric for vital capsules[(4)]. Plants are appreciably beneficial and economically critical. They include energetic materials which are used in the remedy of many human illnesses. They contain active constituents that are used in the treatment of many human diseases. Plants are rich sources of ecologically developed secondary metabolites, which are potential remedies for different ailments. Extreme interest in plants with microbial activity has revived because of current problems such as resistance associated with the use of antibiotics obtained from microorganisms.

Pedalium murex L. (Pedaliaceae) is a diffuse, more or less succulent herb discovered near the seacoast of South India. *P. murex* is native to Africa and Asia. It is disbursed in maximum of the dry and coastal regions of Africa and Asia. In Asia, the species is distributed in Arabian Peninsula (Yemen) and Indian Subcontinent (India and Sri Lanka) (Figure 1). In India, it is especially widespread in waste places of saline sandy areas alongside river belts of Tamil Nadu, Andhra Pradesh, Haryana, Delhi, Rajasthan, Punjab, Gujarat and Madhya Pradesh, Uttar Pradesh etc. Nanomaterials are expected hopefully to revolutionize cancer diagnosis and therapy. Recently, cobalt nanoparticles [5] have been used in anticancer therapy for several types of Hep-2 cell lines, HT-29 cell lines, Vero cell lines and breast cancer line MCF-7. In the present study, we synthesized the cobalt oxide nanoparticle by using bacteria and investigated their anticancer activity against breast cancer cell lines (MCF-7). *Pedalium murex L* is one of the famous traditional medicinal plants in Tamil Nadu (India), This plant leaves extract was used [6,7] to cure urinary retention, kidney stones, seminal weakness, amenorrhea, inflammation, flatulence and fever.

Fig 1. Image of *Pedalium murex L* leaves

2 Methodology

2.1 Collection of Sample

We collected young, healthy leaves of *Pedalium murex L*, also known as Yanai nerunjil in Tamil, from the botanical garden maintained by Government Arts College, Chidambaram. To get rid of any dust particles, the leaves were thoroughly cleaned three times with ordinary tap water (OTW) and then again with double distilled water (DDW). The cleaned leaves were set to air dry at room temperature. An electric mixer was used to grind the dried leaves to powder. The leaf extracts were made with this powder.

2.2 Plant material processing

About five grams of powdered healthy Pedalium murex L. leaves were heated for 20 min at 80oC in a 250 mL round-bottomed flask together with 50 ml of double-distilled water (DDW). Next, Whatman 1# filter paper was used to filter the extract. The filtrate was utilized in the process's subsequent green synthesis.

2.3 Biosynthesis procedure

In a conical flask, 90mL of homogenous cobalt nitrate solution [8] was taken, and then 10 mL of *Pedalium murex L* leaf extract was added gradually in order to reduce cobalt nitrate to cobalt oxide NPs. The mixture was then continuously heated to 70°C and stirred in a magnetic stirrer at 600 rpm for 3 hr equipped with a heating device till the formation of reddish pink colour. Now, 0.1M NaOH solution which was maintained at pH ~10 is added with continuous stirring till the solution turns to blue precipitate. Whatmann No 1# filter paper is used to filter the precipitate. Then the precipitate was ground into a powder, dried, and then heated to 350°C in a muffle furnace. Following calcination, finely crystalline cobalt oxide nanoparticles were obtained which were grey in color. Ultimately, Co_3O_4NPs underwent a steady characterization.Figure 2 displays a scheme of green synthesis.

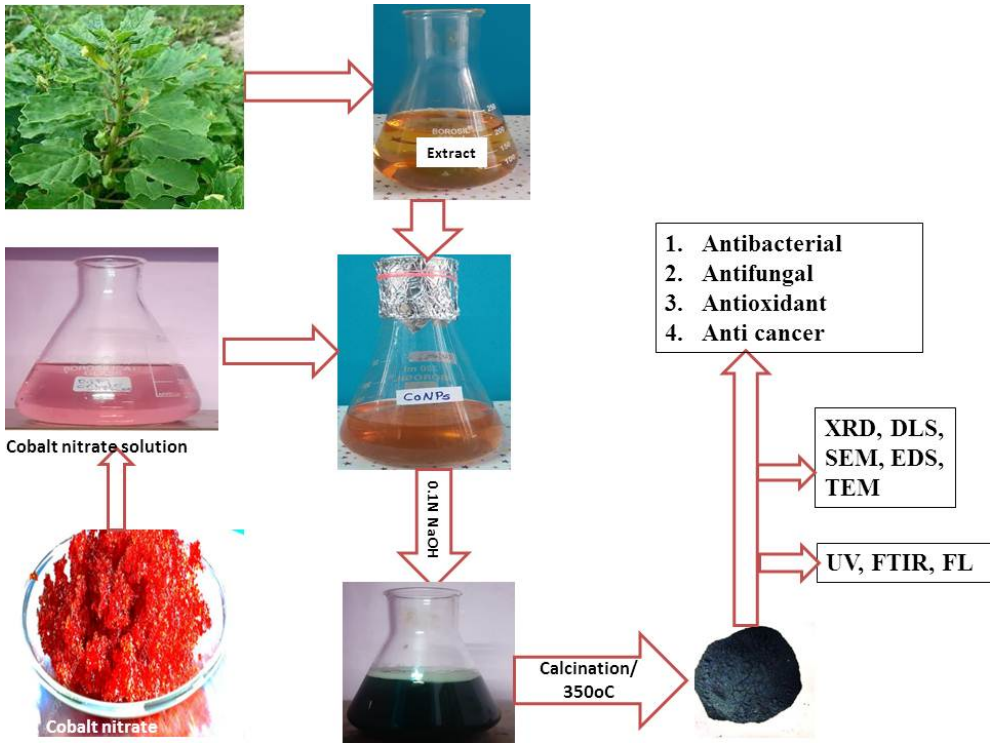

Fig 2. Scheme of Green synthesis of cobalt oxide nanoparticles by *Pedalium murex L.*

2.4 Characterization of Co_3O_4 nanoparticles

Various instrumental techniques including UV, IR and Fluorescence spectra were carried out. The morphological investigation was also carried out for present biosynthesized Co_3O_4 NPs. The solid state dispersions of Co_3O_4NPs were evaluated with X-ray powder diffraction. Diffraction patterns were obtained using an XPERT-PRO diffractometer (PAN analytical Ltd., the Netherlands) with a radius of 240 mm. DLS analyses were examined by the average size of the particle size with 2θ data gathered at temperatures between 20° and 80°. When the NPs had completely dispersed in water, they were analyzed with a DLS analyzer. Using a 10kV acceleration voltage and a scanning electron microscope (SEM with EDS; instrument from Nikon, Japan), the surface morphology of the samples was examined. The gold coating was applied to the samples before analysis. The particle size and microstructure were studied by high resolution transmission electron microscopy in a JEOL 3010, Japan, operating at 200 kV according to the method with some modifications. Four pathogenic bacterial strains, two gram positive (*Staphylococcus aureus, Escherichia coli*) and two gram negative (*Pseudomonas aeruginosa, Bacillus cereus*) and two fungal strains (*Candida albicans, Trichoderma viride*) were used in this assay. These strains were collected from microbiological department of the Center of Advanced Study (CAS) in Marine Biology, Annamalai University, Portonova. Bactericidal activity was determined by using the disc diffusion method. Bacterial cultures were refreshed in nutrient broth for 24 h at 37°C. Antioxidant activities were examined by DPPH method; finally the anticancer activity of the green synthesized cobalt oxide nanoparticles against MCF-7 cancer cell line was screened.

3 Result and discussion

3.1 UV Spectral analysis

The UV–vis spectra were (Figure 3 **a**) recorded[9–11] for the *Pedalium murex L.* leaves extract with cobalt ion. This spectra shows a well-defined surface plasmon band centered around 532.28 and 797.83 nm for cobalt oxide nanoparticles, which is the characteristic absorbance of cobalt oxide nanoparticles. The bands of cobalt nanoparticles suggest a charge transfer effect from the ligand to the metal as $O^{2-} \rightarrow Co^{2+}$, a charge transfer effect from the ligand to the metal as $O^{2-} \rightarrow Co^{3+}$ respectively,which proves that the cobalt ion is correctly reduced by the leaf extracts.

3.2 FL Spectroscopy

This study investigated the fluorescence emission spectra of cobalt oxide nanoparticles. The spectral characteristics of fluorophores have to shape the wavelengths of the excitation mild, Dichroic and emission filters of the fluorescence microscope on which the experiments are to be done. Furthermore, it's far recommended that their spectra are nicely separated from the spectra of other fluorophores with the purpose of being used simultaneously in the experiments to decrease pass-talk and bleed through, which can provide rise to [12] false co-localization and misinterpretations if no longer appropriately corrected. To be used with superior optical strategies (together with higher solution microscopies, two-photon microscopy, fluorescence lifetime imaging, spectral imaging, or correlation spectroscopy), in addition, photo-physical factors (e.g., lifetime, blinking, and environmental sensitivity) should also be taken into consideration.Figure 3 **b** indicates the fluorescence emission of cobalt nanoparticles by aqueous leaf extracts of *Pedalium murex L*. It suggests that the plasmonic resonance inside the variety is close to 765 nm.

3.3 FT-IR spectroscopy

FTIR analysis for the biogenically synthesized cobalt oxide nanoparticles and the leaf extract of *Pedalium murex L* were carried out in order to explore the formation of cobalt oxide nanoparticles and confirm the functional groups present in the aqueous leaf extract. Figure 3(**c-d**) shows the FTIR spectra of aqueous leaf extract of *Pedalium murex L*. and Co_3O_4NPs by *Pedalium murex L* which were recorded in the range of 4000–400 cm^{-1}. The broad peak observed at 3423 cm^{-1} represents the O-H stretching. The absorption peak observed at 2146 cm^{-1} reveals the presence of C-H stretching vibrations of an aromatic aldehyde. The medium absorption peak observed at 1631 cm^{-1} corresponds to C=O peak, which indicates the ketone functional group. The band observed at 1385 cm^{-1} corresponds to C-C stretching of the aromatic groups obtained from the leaf extract of *Pedalium murex L*. An absorption peak found at 1271 cm^{-1} corresponds to the saturated primary alcohol containing the C-O bond; the sharp peak at 1115 cm^{-1} reveals that O-C stretching vibration.

The small peak observed at 831 cm^{-1} reveals the S-OR ester stretching vibration and 604 cm^{-1} reveals the carbon-carbon chain linkage. The FTIR spectrum of *Pedalium murex L*. leaves extracts capped Co_3O_4NPs is shown in Figure 3**d**. This spectrum implies that cobalt oxide exhibits two major bands which are observed at 663 cm^{-1} and 570 cm^{-1}. The first band is associated with the Co^{3+} vibration in the octahedral hole and the second band at 570cm^{-1} is attributed to the Co^{2+} vibration in the tetrahedral hole, which confirms the formation of the Co_3O_4 spinel [13]. The frequency of 3434 cm^{-1} reveals the O-H stretching of phyto-constituents, 1631 cm^{-1} indicates carbonyl stretching vibration, 1438cm^{-1} indicates the deformation modes of -CH_2- and -CH_3 bending vibrations and the weak peak at 1271cm^{-1} reveals that =CH_2 bending vibration. While the peak at 954, 864, and 765 cm^{-1} evidences the C=C bending vibration (in-plane & ring torsion). From these observations, the only water soluble phytoconstituents are observed in FTIR spectrum of Figure 3 **a**. In case of FTIR in Figure 3 **b**, some peaks are reduced and formed new peaks especially the two new peaks at 663cm^{-1} and 570cm^{-1} indicates the presence of reduced cobalt (Co^{3+} and Co^{2+}) ions. The first band is associated with the Co^{3+} vibration in the octahedral hole and the second band (ν) is attributed to the Co^{2+} vibration in the tetrahedral hole, which confirms the formation of the Co_3O_4 spinel structure.

3.4 XRD Analysis

The X-ray diffraction (XRD) method is used to determine the purity and section of the powdered cobalt oxide nanoparticles from aqueous leaves extract of *Pedalium murex L*. Figure 3 **e**, represents the standard diffraction peaks i.e., observed at 2θ values at 13.22, 23.37, 28.64, 32.28, 34.76, 46.18, 49.71, 56.26, 62.59 A^o corresponds to the spinel shape and cubic near packed segment [JCPDS card no.–01-073-1701] of Co_3O_4 NPs. Insignificant peaks are discovered could be attributed to natural materials [14]. A shift in some peaks indicates the presence of impurities in the biomass residue. The presence of extensive peaks shows the synthesized particles to be very small and amorphous in nature. The common crystallite size is determined by means of the Scherer formula, D = zero.9λ/β cosθ. The crystallite length of naturally synthesized Co_3O_4 NPs, similar to the best peak discovered in the XRD pattern is about 55.8 nm. The common crystallite length was observed to be in the range of ~21.8. This belongs to Co element present and it marks the nanoparticles smaller (4.9 nm). The number of Bragg values of Co_3O_4NPs by *Pedalium murex L* leaves (111, 220, 311, 222, 400, 422, 511, 531) by XRD pattern indicates the cobalt oxide nanoparticles.

3.5 DLS Analysis

DLS is the most often applied technique to determine the distribution of Cobalt oxide nanoparticles size in its condensed state [15]. The evaluated result of nanoparticle size shows that the range of size variation is 8 to 80 nm, and the highest size variation is around 22.48 nm as shown in Figure 3 **f**. Comparatively, the size variation diagram evaluated in DLS analysis has

shown good symmetry and homogeneity of resultant cobalt oxide nanoparticles.

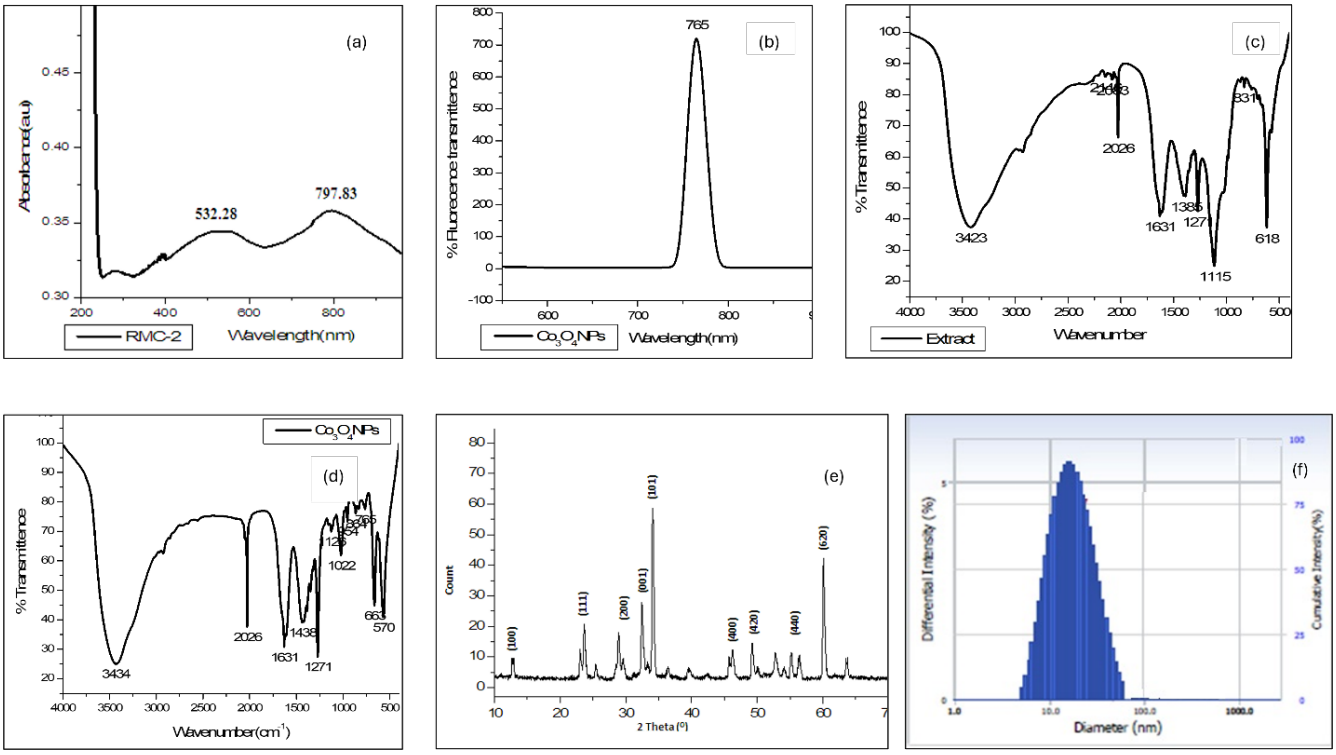

Fig 3. (a) UV Spectrum, (b) FL Spectrum, (c) FTIR Spectrum of leaves extract of *Pedalium murex L*, (d) FTIR Spectrum of cobalt nanoparticles, (e) XRD pattern and (f) DLS Spectrum of cobalt oxide nanoparticles mediated by leaves extract of *Pedalium murex L*

3.6 SEM and EDS analysis

SEM micrographs with high magnification were used to determine the morphology and grain size of all calcined Co_3O_4 NPs. The highly magnified micrograph (Figure 4(**a-d**)) clearly shows that the small particles joined together forming a bunch like structure, where clear boundaries among the particles were seen [16]. Spherical-like particles, mountain rock-shaped polycrystalline particles are also seen. The particle sizes estimated from SEM micrographs using Image J software are 5μm in Figure 4**a**, and 1μm in Figure 4 **b**.

The chemical compositions of synthesized Co_3O_4NPs were measured by EDS analysis [16] and are shown in Figure 4(**e-f**). Both the SEM and EDS images are shown in polycrystalline structure, the spectrum shows the strong EDS peaks associated with Co and O elements in CoO in nanoparticles and other peaks are also obtained in EDS which may be due to the phyto constituents present in *Pedalium murex L* leave extract, which were added during the processing of nanoparticles were found in the EDS spectrum as shown in Figure 4 **f**.

This result shows the percentage of all elements present in the nanoparticles. The EDS results are shown in Table 1.

3.7 TEM Analysis

TEM images (Figure 5) of the present NPs reveal a polycrystalline nature, well-defined and uniform shape. A closer look at the crystal edges also reveals cubic, trigonal, pentagonal and hexagonal shapes [17]. This roughly corroborates the estimates from XRD, DLS and SEM analyses providing values of 100 nm for the above three analyses. The SAED pattern has been shown in the crystalinity of the green synthesis of cobalt oxide nanoparticles.

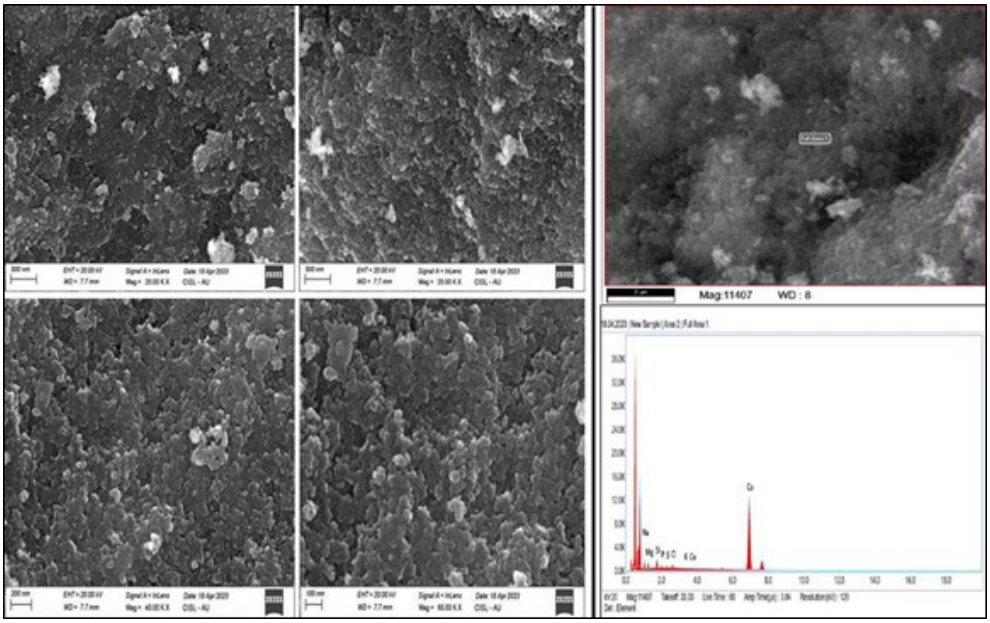

Fig 4. (a-d) SEM images of cobalt oxide nanoparticles, (e-f) EDS micrograph images of Cobalt oxide nanoparticle mediated by *Pedalium murex L*

Table 1. EDS report of cobalt oxide nanoparticle mediated by leave extract of *Pedalium Murex L*

Element	Weight %	MDL	Atomic %	Error %	Net Int.	R	A	F
Na K	7.27	0.35	15.47	13.32	159.13	0.8325	0.098	1.0021
O K	34.13	0.22	34.18	1.89	1558.57	0.8982	0.7984	1.0422
Mg K	2.83	0.19	5.69	13.23	116.18	0.8384	0.1556	1.0033
Si K	2.64	0.11	4.6	9.42	209.1	0.8494	0.3426	1.0083
P K	0.82	0.12	1.3	13.99	66.37	0.8547	0.4459	1.0131
S K	0.52	0.11	0.79	14.01	49.12	0.8598	0.5523	1.0197
Cl K	1.01	0.11	1.39	11.68	95.15	0.8647	0.6441	1.0296
K K	0.29	0.12	0.37	19.95	26.62	0.8744	0.7823	1.065
Ca K	0.4	0.13	0.49	20.05	32.71	0.8792	0.8311	1.0931
Co K	50.09	0.25	35.72	2.16	1512.21	0.9127	0.9699	1.0303

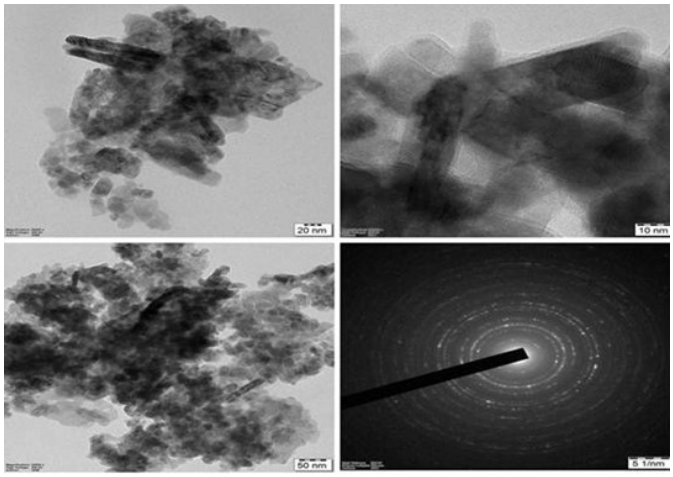

Fig 5. (a-d)TEM images with SAED pattern of cobalt oxidenanoparticles mediated by *Pedalium murex L.*

3.8 Antibacterial and fungal activity

It is well-known that cobalt oxide nanoparticles exhibit a brown color[18]. Cobalt oxide nanoparticles obtained from *Pedalium murex L.* show very strong inhibitory action against Gram-positive and Gram-negative bacteria. Three concentrations of NPs (1000, 750, 500 μg/ml) were prepared and applied against various bacterial species viz., *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus cereus*. The plate of antibacterial activity is shown in Figure 6 and zone of inhibition values are shown in Table 2. The higher concentration (1000 μg/ml) of cobalt oxide nanoparticles showed significant antibacterial effects compared with other concentrations (750 and 500 μg/ml). The species *E. coli* has been strongly inhibited when compared to standard at low concentrations. The green synthesized cobalt nanoparticles with *Pedalium murex L* leave extract have shown excellent activity against gram-negative bacterial strain of *Pseudomonas aeruginosa*, and good antibacterial activity against *Escherichia coli* bacterial strain.

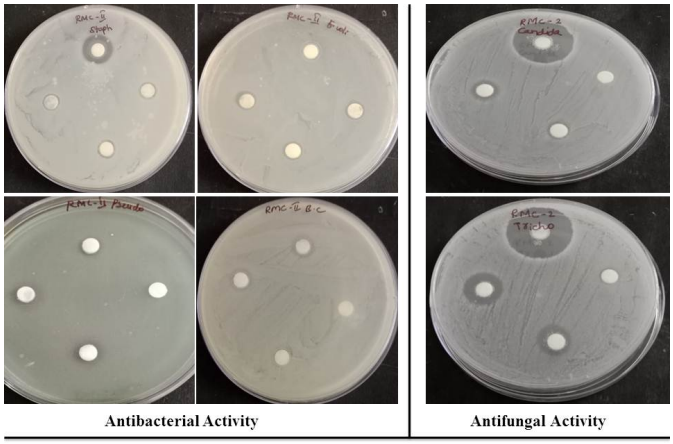

Fig 6. Antibacterialand antifungal activity of cobalt oxide nanoparticles mediated by *Pedalium murex L* . leaves extract

Table 2. Zone of inhibition values of Antibacterial and antifungal of cobalt oxide nanoparticle mediated by leave extract of *Pedalium murex L*

S.No	Concentration (μg/ml)	Antibacterial activity				Antifungal activity	
		Staphylococcus aureus	*Escherichia coli*	*Pseudomonas aeruginosa*	*Bacillus cereus*	*Candida albi-cans*	*Trichoderma viride*
1	**1000**	12	11	12	11	10	15
2	**750**	10	10	11	9	8	11
3	**500**	8	8	7	7	7	7
4	**Standard**	15	8	9	11	25	26

The findings in this study may lead to the development of cobalt nanoparticle-based new antibacterial systems for medical applications[19,20]. The antifungal activity of cobalt nanoparticles with *Pedalium murex L.* has shown poor activityfor all three concentration solutions, 1000, 750 and 500 μg/ml.

3.9 Antioxidant activity

The DPPH assay is widely used for screening antioxidant activity because it is sensitive to detect active compounds at low concentrations[21]. DPPH is a nitrogen-centered free radical, and hence any compound that scavenges significant amounts of DPPH could reduce levels of other reactive nitrogen species in living cells. Ascorbic acid is used as the standard drug.

From our results, the cobalt oxide nanoparticles of *Pedalium murex L.* leaves extract quenched DPPH free radicals appreciably and dose-dependently (200, 400, 600, 800 and 1000 μg/mL). A cobalt oxide nanoparticle, however, has no known mechanism of action as an antioxidant as this is one of the earliest reports on its antioxidant effect on DPPH free radicals. Hence, the

reason for its relatively lower antioxidant activity compared to DPPH cannot be adequately explained. The inhibition values of antioxidant activity are shown in Table 3. DPPH is a stable nitrogen-centered free radical with a distinctive absorption at 520 nm that changes color from violet to yellow upon reduction.

Table 3. Antioxidant activity of cobalt oxide nanoparticle mediated by leave extract of *Pedalium murex L.*

S.NO	Concentration (μg/ml)	OD AVERAGE	DPPH %
1	200	0.444	25.62
2	400	0.397	33.50
3	600	0.314	47.40
4	800	0.224	62.47
5	1000	0.150	74.87

3.10 Anticancer

In vitro cytotoxic activity against the MCF-7 cell line at different concentrations was evaluated and compared with the standard drug cyclophosphamide. The anticancer activities of the cobalt oxide nanoparticles were performed at different concentrations, such as 7.8, 15.6, 31.6, 62.5, 125, 250, 500 and 1000 μg/ml. The anticancer activity of cobalt oxide nanoparticles against the MCF-7 breast cancer cell line increased in the concentration of cobalt oxide nanoparticles (Figure 7). Cobalt oxide nanoparticles exhibit good results when compared with the standard cyclophosphamide. The results show good cytotoxic activity against cancer cells. The concentration of cobalt oxide nanoparticles plays an important role in anticancer activity[22,23]. The cobalt nanoparticles have good results against MCF-7 lines in that 62.5 μg/ml show fine results by 125, 250, 500 and 1000 μg/ml. The lowest inhibitory action was observed from a concentration of 250 μg/ml. In this report, the anticancer activity was observed and the synthesized cobalt oxide nanoparticles were a dose-dependent inhibition activity against human breast cancer cells[24]. Some of the approved chemotherapeutic agents caused side effects and high costs[25]. IC_{50} value measurements were performed and the concentration required for a 50% inhibition was determined graphically. Therefore, there is an important need to develop alternative medicines against this deadly disease. Synthesized cobalt oxide nanoparticles to fulfill the need for new therapeutic treatments were discovered.

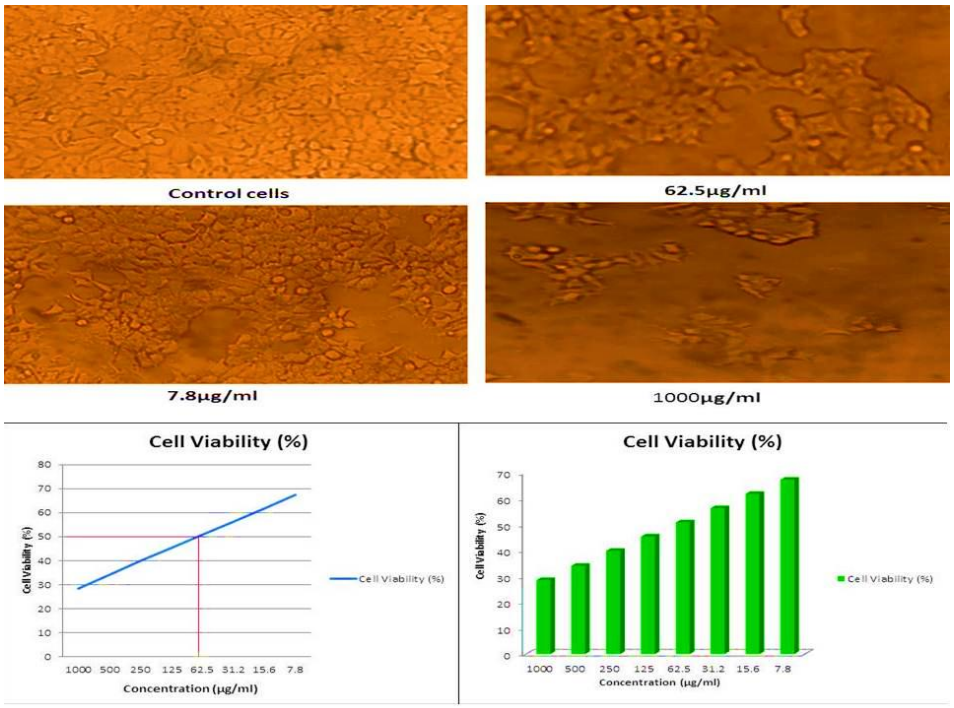

Fig 7. Anticancer activity of cobalt oxide nanoparticles by *Pedalium murex L.* leaves extract on MCF-7 breast cancer cell line

4 Conclusion

Green syntheses of cobalt oxide nanoparticles were achieved by using leaf extract of *Pedalium murex L*. and were initially identified by a formation of the deep blue color precipitate by visual observation. UV–vis spectrophotometer analysis shows the absorption band at 532.28 and 757.83 nm indicating the greater number of unsaturated bonding of phyto constituents present in *Pedalium murex L*. Fluorescence spectra at 765 nm responded to the cobalt oxide nanoparticles. Many organic phytoconstituents in the *Pedalium murex L* has been shown in the FTIR spectrum of leaf extract. Another FTIR spectrum of cobalt oxide with leaf extract has shown the reduced transmittance percentage of various organic functional groups. The major peaks observed at 663 and 570 cm^{-1} indicated the spinel structure of cobalt oxide nanoparticles. The crystalline structure of cobalt oxide nanoparticles and their size, shape and distribution of nanoparticles were confirmed by XRD and DLS. SEM with EDS, TEM with SAED pattern images. Good antibacterial activity has been shown against two gram positive bacterial strains, but better activity has been shown on the two gram negative antibacterial pathogens. Pseudomonas aeruginosa responded well with cobalt oxide nanoparticles synthesized by *Pedalium murex L*. extract. Increased anticancer activity on the MCF-7 breast cancer cell line can be achieved with an increased concentration of cobalt oxide nanoparticles, $IC_{50,}$ 80 g/mL observed in a concentration of 62.5 μg/ml. This green approach was easy, large, scaled up and eco-friendly. Thus, synthesized nanoparticles are more efficient especially in biomedical applications including cancer treatment because of their high anticancer activity.

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